PUBLIC HEALTH ASSESSMENT

MACALLOY CORPORATION

NORTH CHARLESTON, CHARLESTON COUNTY, SOUTH CAROLINA

CERCLIS NO. SCD003360476

Prepared by

The South Carolina Department of Health and Environmental Control

Division of Health Hazard Evaluation

Under a Cooperative Agreement with the

Agency for Toxic Substances and Disease Registry

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SUMMARY

The Macalloy Corporation once produced ferrochromium, an alloy of iron and chromium, from chromite ores. The alloy was used to manufacture high-grade stainless alloy steel. Ferrochromium alloy was produced by smelting chromite ore mixtures in large electric submerged arc furnaces. Historically, as many as twelve furnaces were used to produce the alloy. Alloy manufacturing results in the generation of slag fine, particulate matter, ashes, dust, and baghouse dust (U.S. EPA, 1999). This type of operation produces four main kinds of waste: electrostatic precipitator dust (ESP); baghouse dust; gas conditioning tower sludge (GCT) and wastewater. Past inspections by SCDHEC have found many violations pertaining to the management and treatment of ESP dust (U.S. EPA, 1994).

The Site was proposed to the National Priorities List (NPL) on October 22, 1999 and became Final on February 4, 2000. U.S.EPA began work on the Remedial Investigation/Feasibility Study on March 29, 2000. The initial Phase I Remedial Investigation field sampling and characterization started in June 2000. The report was finalized in April 2001. Phase II field efforts were conducted in June 2001, and this report was finalized in spring 2002. The proposed plan was released for public comment in April 2001 and the record of decision is expected by summer 2002.

Under ATSDR's classification system, the Macalloy site would be classified as an indeterminate public health hazard in the past. It is possible that former workers were exposed to lead, chromium, and manganese while working at the facility. However, we have no information to fully evaluate this exposure pathway. It is also possible that people catching and eating shrimp and blue crabs caught near the site could have been exposed to chromium. Current chromium concentrations in shrimp are below levels of concern.

Currently, the site poses no apparent public health hazard. This means that based on current conditions at the site, we do not think people are being exposed to site-related chemicals at levels that would cause adverse health effects.

Environmental monitoring data has shown that on-site surface water, sediment, soil, and waste materials are contaminated with site-related chemicals above screening levels. Sediments, surface water, and biota from Shipyard Creek also contained site-related chemicals. Groundwater at the site is also contaminated, however, a pump and treat remediation system has been in place for several years. North Charleston residents are on public water supplied through surface water and will not be exposed to contaminated groundwater water.

The following recommendations have been made: SCDHEC-HHE will review the information collected as part any future work (if any) at the Macalloy site.

BACKGROUND

The South Carolina Department of Health and Environmental Control (SCDHEC), under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), evaluated the public health significance of the Macalloy Corporation. SCDHEC-Health Hazard Evaluation (HHE) determines whether exposure to contaminants is likely to cause adverse health effects and recommends actions to reduce or prevent possible health effects. ATSDR is authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by SARA, to conduct public health assessments at hazardous waste sites.

A. Site Description and History

The Macalloy Corporation is at 1800 Pittsburgh Avenue, North Charleston, Charleston County, South Carolina (Figure 1, Appendix A). It is a 125-acre site bounded on the west by CSX Railroad; on the east by Shipyard Creek, a tributary of the Cooper River; on the south by a metal scrapyard and private shipyard; and on the north by a waste-to-energy plant (U.S.EPA, 1998). The Charleston Naval Shipyard is east and north of the facility. Industrial and commercial properties surround the site. There is a residential neighborhood about 600 feet northwest of the facility property line (U.S.EPA, 1996). The facility closed in 1998.

The Macalloy Corporation once produced ferrochromium, an alloy of iron and chromium, from chromite ores. Ferrochromium alloy was used to manufacture high-grade stainless alloy steel. Ferrochromium alloy was produced by smelting chromite ore mixtures in large electric submerged arc furnaces. Historically, as many as twelve furnaces were used to produce the alloy. Alloy manufacturing results in the generation of slag fine, particulate matter, ashes, dust, and baghouse dust (U.S. EPA, 1999). This type of operation produces four main kinds of waste, electrostatic precipitator dust (ESP), baghouse dust, gas conditioning tower sludge (GCT), and wastewater. Past inspections by SCDHEC have found many violations pertaining to the management and treatment of ESP dust (U.S. EPA, 1994).

Areas of concern at the Macalloy site include; an unlined surface impoundment (ESP dust pile), the NPDES settling pond, the groundwater recovery and treatment system, and Shipyard Creek. ESP dust and slurry were placed in the unlined surface impoundment. At one time, the ESP dust pile was around 200 by 350 feet around by 40 feet high (U.S.EPA, 1999). Half of the material has been removed by SCDHEC RCRA. The remainder of the pile is covered. ESP dust and baghouse dust are high in hexavalent chromium (U.S.EPA, 1996). The gas conditioning towers were used in the treatment process of the ESP dust. This process generated sludge, which was once put in piles to dry and then spread out in the ore storage area. The sludge contains both chromium and lead. GCT sludge has been used as fill material across the site. Wastewater from the gas conditioning towers and settling basins were piped to the NPDES pond. After settling, the water was discharged via NPDES outfall 001. There were four NPDES permitted outfalls at the facility, 001, 002, 003, and 004. All four of these outfalls discharge into Shipyard Creek (U.S.EPA, 1998). Water samples from the outfalls collected pursuant to the

requirements of the NPDES permit, have repeatedly exceeded permit limits for total chromium and hexavalent chromium (U.S. EPA, 1999).

A brief site history, including operations and waste disposal, is provided below.

- •Before 1941 the property was used for a rice plantation and lumber mill.

- •From 1941 to 1966, the facility was owned and operated by Pittsburgh Metallurgical Company. The Airco Corporation operated the facility from 1966 to 1979. Macalloy Corporation has owned and operated the facility since 1979. The company closed in 1998.

- •Prior to air regulations, around 1970, particulate matter, ashes, and dust were discharged directly to the atmosphere.

- •From 1970 to approximately 1981, untreated ESP dust was stockpiled in many areas around the site. ESP dust was also used as fill at the site and stored in the on-site impoundment.

- •Untreated ESP dust was sent to Stoller Chemical in Jerico, South Carolina from 1981 to 1992.

- •From 1988 to 1997 ESP dust was either left on-site or sent to Stoller Chemical.

- •Groundwater contamination was detected at the facility in the early 1990s. Groundwater beneath the site contains high levels of hexavalent chromium. A SCDHEC-approved water remediation plant was used to treat on-site contaminated groundwater. The system was turned off in June of 2002.

- •In December 1992, SCDHEC issued an administrative order to address groundwater contamination at the site.

- •Samples of ESP dust, GCT sludge, sediment, and ponded water in the unlined surface water impoundment collected by EPA in 1993, contained elevated levels of chromium. Surface water samples contained hexavalent chromium at 32 mg/L (TLCP method).

- •The United States Environmental Protection Agency (U.S.EPA) completed a RCRA Case Development Investigation Evaluation at the site in February 1994.

- •A RCRA Facility Assessment (RFA) was completed by U.S. EPA in 1995. This report concluded that soil and groundwater were contaminated because of waste management practices at the facility.

- •In May 1995, SCDHEC issued a Unilateral Administrative Order to Macalloy for past RCRA violations.

- •In 1996, EPA and SCDHEC conducted a multimedia inspection at the facility. Samples were taken from the wastewater discharge outfalls.

- •During an EPA-SCDHEC storm water inspection in 1997, investigators noted evidence of discharge of stormwater into Shipyard Creek and nearby wetlands. EPA collected samples of soil, sediment, and stormwater discharges.

- •Water samples collected by EPA in July 1997 from unpermitted stormwater run-off contained high levels of contaminants including total chromium up to 10 mg/L and hexavalent chromium. This surface water run-off flows from the facility into Shipyard Creek (U.S.EPA, 1998).

- •Sediment samples collected by EPA in July 1997 contained extremely elevated levels of chromium (4,700 mg/kg highest concentration).

- •Shrimp, crab, and oyster samples collected from Shipyard Creek in 1997 had elevated levels of chromium. This led to a SCDHEC closure of the creek for shrimping and crabbing in April 1998. SCDHEC revised the closure to a reduced consumption advisory in March 2000.

- •|Additional samples of shrimp and crab were collected in November 2001. Much lower levels of chromium were detected and SCDHEC rescinded its consumption advisory in November 2001.

- •GCT sludge containing cadmium, chromium, lead, mercury, nickel, and zinc were used as fill across the property.

- •In the last years of operation, baghouse dust was treated and pumped to the surface water impoundment.

- •Process-related wastewater generated in the gas conditioning towers was discharged to the concrete settling basin.

In June 1998, the Macalloy Corporation installed interim surface management controls via a CERCLA Section 106 Removal Action Administrative Order of Consent (AOC) with EPA. This action involved the construction of berms, diversion structures, and detention basins to facilitate removal of solids from stormwater run-off, before discharge. During the Fall of 1999, an estimated 40,000 tons of electrostatic precipitator dust was excavated, treated if necessary, and hauled to a RCRA Subtitle D landfill for disposal. The remaining berm material has been characterized as RCRA nonhazadous waste and will be addressed as part of the Site-wide remedy developed under the CERCLA Record of Decision (U.S.EPA,

2000).

The Site was proposed to the National Priorities List (NPL) on October 22, 1999 and became Final on February 4, 2000. U.S.EPA began work on the Remedial Investigation/Feasibility Study on March 29, 2000. The initial Phase I Remedial Investigation field sampling and characterization started in June 2000. The Phase I investigation was finalized in April 2001. Phase II field efforts were conducted in June 2001. The Proposed Plan was released for public comment in April 2002 and the ROD is expected by summer 2002.

B. Site Visit

HHE staff visited the site on September 25, 2000. The facility is fenced with a guarded gate at the entrance. The site is surrounded by commercial properties and there are no homes along Pittsburgh Avenue. There are also commercial properties along Spruill Avenue which runs north to south, along the western side of the site. Although the closest homes are about 600 feet from the property line, the actual buildings at the facility are about a half-mile further down Pittsburgh Avenue from these homes. Although people can drive or walk down Pittsburgh Avenue, they cannot get onto the property without permission.

C. Demographics, Land Use, and Natural Resource Use

The Macalloy site is in North Charleston, Charleston County, South Carolina. The site is in an industrial and residential area of North Charleston. The total population within one mile of the site is about 8,500. About 17,700 people live within two miles of the site. The demographic profile of the population around the site includes a population that is about 50 percent white, 44 percent black, and 4 percent Hispanic. The demographic profile changes to 60 percent black and 36 percent white within a two-mile radius. Twenty-five to fifty percent of the people living close to the site live below the poverty level.

Land use is about 70 percent industrial and 30 percent residential (Tetra Tech, 1998). The former Charleston Naval Shipyard is directly across Shipyard Creek from Macalloy. Adjacent land use includes a private shipyard and metal scrapyard, a large petroleum storage facility, and a county incinerator. Across the railroad tracks and Spruill Avenue, is a

residential community. There are also homes south of the facility.

Shipyard Creek is a tributary to the Cooper River. Surface water runoff from the site enters Shipyard Creek through a wetland or marsh area. Both Shipyard Creek and the Cooper River are used for recreational fishing. The Cooper River, approximately 0.75 of a mile downstream from the Macalloy facility, is used for fishing, boating, and water skiing. The Cooper River flows toward the south-southwest for four miles to enter Charleston Harbor. The tidal effects of the Atlantic Ocean influence Shipyard Creek and the Cooper River.

D. Health Outcome Data

No health outcome data are readily available for review for this part of North Charleston.

COMMUNITY HEALTH CONCERNS

HHE contacted SCDHEC Environmental Quality Control and Health Districts for information regarding health concerns related to the Macalloy site. Neither of the offices have reports of site-specific health concerns. In June 2000, the U.S.EPA held a public meeting to initiate their activities at the site. None of the residents at this meeting reported any health concerns to EPA staff.

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

Environmental monitoring data from several RCRA investigations, storm water inspections, SCDHEC investigations, and U.S.EPA investigations were available for review. Most of the samples were collected on the site. Most of the off-site samples were collected in Shipyard Creek during the 1998 U.S.EPA investigation. None of these investigations include a complete environmental assessment of the Macalloy site. A comprehensive investigation will be completed as part of the superfund investigation and clean-up process at the site.

Screening values for public health assessments are contaminant concentrations in specific media used to select contaminants for farther evaluation. These values include U.S.EPA Maximum Contaminant Levels (MCLs), those calculated by SCDHEC, ATSDR's Environmental Media Evaluation Guides (EMEGs), and other relevant guidelines. EMEGs are derived from ATSDR Minimal Risk Levels (MRLs). EMEGS are the estimates of a daily human exposure to a chemical likely to be without an appreciable risk of non-carcinogenic adverse effects. MCLs are the maximum permissible levels of contaminants in public water. The South Carolina Water Classifications and Standards (SCWCS) are the maximum permissible level of contaminants in surface water developed by the state of South Carolina for protection of human health.

A. On-site Contamination

Most of the samples collected on-site included, surface water, sediment, waste, and soil samples. Surface water was collected from standing water, puddles, the surface water impoundment and basin. Sediment and surface water samples were collected from drainage pathways on the site. It is clear from the investigations at the site that surface water, sediment, and soil are contaminated with site-related chemicals. Since waste materials from plant operations have been used as fill across the property, waste materials remaining on site are contaminated with chromium, lead, nickel, and zinc. Some surface water was green-tinted, indicative of chromium contamination. The early investigations were completed by U.S.EPA and SCDHEC-RCRA and water programs. Most of the samples during the early investigations were only analyzed for eight RCRA metals.

The 1993 SCDHEC investigation involved the evaluation of soil (one sample), waste material, and surface water. The samples were only analyzed for eight RCRA metals. Soil contained elevated levels of chromium (1,300 milligrams per kilogram, mg/kg), and low levels of barium and lead. Chromium concentrations were below the 2,100 mg/kg screening level for hexavalent chromium. Surface water and waste samples (slag and dust) contained elevated levels of total chromium and lead. The highest concentration of chromium (5,000 mg/kg) and lead (4,000 mg/kg) were found in a sample of untreated ESP dust. Both the chromium and lead exceeded their respective screening levels. Surface water samples collected from standing water contained 0.4 to 12 mg/L of chromium (SCDHEC, 1993).

The next year the U.S.EPA completed a RCRA-Case Development Investigation Evaluation (CDIE). Four surface water samples, one sediment sample, two sludge samples, and three dust samples were collected at the site. Waste samples consisted of treated and untreated ESP dust. Surface water and waste samples contained elevated levels of total and hexavalent chromium, nickel, lead, and manganese (Table 1, Appendix B). Hexavalent chromium levels in surface water were as high as 32 mg/L in a sample from the old surface water impoundment. Treated ESP dust/slurry contained very high levels of total chromium (530 mg/L) (U.S.EPA, 1994).

The third investigation at the Macalloy site was a 1995 SCDHEC investigation. Three surface water samples, three waste samples, one soil sample, and two water samples from Shipyard Creek were collected during this investigation. Low levels of chromium (0.12 mg/L) were detected in one of the Shipyard Creek samples. There were no RCRA metals detected in the second Shipyard Creek sample. On-site surface water collected from standing water contained elevated levels of chromium (2.8 mg/l to 82 mg/L) and lead (0.6 mg/l). Chromium concentrations were much lower in this round of samples than in either of the first two investigations. A sample of dust contained 5,100 mg/kg of chromium and 2,200 mg/kg of lead. This sample also contained low levels of barium, mercury, cadmium, and arsenic. Chromium concentrations were also elevated (990 mg/kg) in the single soil sample collected, but concentrations were below screening levels (2,100 mg/kg) (SCDHEC, 1995)

The 1997 U.S.EPA-RCRA Stormwater Inspection was conducted at the Macalloy Corporation plant to determine if the company was in compliance with stormwater regulations. Samples were restricted to surface water and sediment. Samples were collected from on-site gullies and surface water drainage pathways. The findings of this investigation are consistent with previous investigations at the site. Both water and sediment contained elevated levels of chromium, lead, manganese, and arsenic (Table 2, Appendix B). These sample results have shown that drainage pathways to Shipyard Creek are contaminated with site-related chemicals, particularly chromium. Water samples collected near the old outfall (002), contained very high levels of chromium (10 mg/L). A ditch leading to this outfall contained 9.8 mg/L of chromium(U.S.EPA, 1997).

The Phase I Remedial Investigation (June to October 2000) was undertaken to fill data gaps and collect information for the risk assessment, remedial design, and future site use. Soil, groundwater, sediment and surface water samples were collected from on-site sewers and drainage ditches. Samples were collected from the ESP dust storage/treatment area, casting bay furnace area, surface water impoundement, the northern marsh fill area, solid waste landfill, and the petroleum sites. Sediment samples were collected from the settling canal. Surface water samples were collected from three locations; the intake and out-take of the settling canal, and the effluent of one of the on-site storage basins. This basin (002B) was created in 1998, as part of the completion of the interim surface water management system. This basin receives treated groundwater and storm-water runoff from the raw materials storage area and the USI areas. Soil samples contained elevated levels of total chromium, concentrations above the soil screening level. However, in general hexavalent chromium levels were below levels of concern (soil screening levels).

B. Off-site Contamination

The Marine Resources Research Institute (MRRI), South Carolina Department of Natural Resources, has been involved in

a variety of environmental monitoring programs that include sampling and analysis of sediments, water, and biological tissues from Shipyard Creek. The samples were collected as part of the Environmental Monitoring and Assessment Program (EMAP) for the Carolinian Province study. EMAP is sponsored jointly by NOAA and the U.S. EPA. These studies have documented significant elevations of chromium, and other metals such as nickel, cadmium, and zinc, in the sediments of Shipyard Creek.

Two hundred shrimp, blue crab, oyster, and fish samples were collected from Shipyard Creek during the summer of 1997 as part of a regional assessment of the status and trends in ecological conditions of estuaries throughout the southeastern United States. Only edible portions were used for the analysis. The samples were analyzed by two different methodologies, instrumental neutron activation analysis (INAA) and atomic absorption (AA). The INAA results are presented as total chromium in Table 3, Appendix B. Chromium concentrations in these samples exceeded the consumption advisory levels for chromium as shown in Appendix C. Two sediment samples were collected from one area in Shipyard Creek during the summers of 1994 and 1995. The samples were analyzed for chemical contaminants and toxicity bioassays. Total chromium was detected at 1911 mg/kg in 1994 and 20,660 mg/kg in 1995 (U.S.Department of Commerce, NOAA Correspondence, 1998).

Twelve additional shrimp samples were collected in the fall of 2001. Total chromium concentrations were low, ranging from 0.25 J mg/kg to 0.91 J mg/kg. The maximum concentration detected in these samples is below the consumption advisory limits for chromium as shown in Appendix C. An Administrative Law Judge ordered SCDHEC to lift the advisory on November 12, 2001.

Most of the off-site sediment and surface water samples were collected from Shipyard Creek as part of the 1998 U.S.EPA investigation. This investigation was completed as part of a superfund evaluation at the site. Its purpose was to determine the nature and extent of contamination in sediments and surface water in the marsh and upper area of Shipyard Creek.

Twenty sediment and fifteen water samples were collected in Shipyard Creek. Three samples were also collected from a reference creek. An additional 15 samples were collected from the wetland area across from Macalloy. Sediment samples were collected at one, two, and three-foot depths. Since Shipyard Creek is influenced by the tides, water samples were collected from several sample stations at high and low tide. Seven of the twenty water samples were analyzed for hexavalent chromium (U.S.EPA, 1998). One of these seven samples contained 21 mg/kg of hexavalent chromium. This round of sampling showed that sediment and water in the creek contain site-related chemicals (Table 4, Appendix B). In addition, water samples collected at high tide had higher metal concentrations than those collected from the same location at low tide. The highest concentrations of site-related chemicals in sediments were found near the former NPDES outfalls 001 and 002, and in various locations scattered around Shipyard Creek. The highest concentrations are found closest to the Macalloy facility. Sediment samples collected from marsh areas downstream of the Macalloy had much lower metal concentrations (U.S.EPA, 1998). Although sediment samples contained elevated levels of total chromium, only one sample contained hexavalent chromium, however, only seven of the samples were analyzed for hexavalent chromium.

A few sediment samples were collected in Shipyard Creek as part of the 1998 NPDES Monitoring Report at the Macalloy facility. Chromium was elevated in only two of the samples, collected next to the Macalloy site (LAW, 1998). Sediment samples were also collected as part of the Preliminary Ecological Risk Evaluation completed in July 2000. Total chromium concentrations in Shipyard Creek ranged from 8.3 to 1,300 mg/kg which are below the comparison value for chromium (2100 mg/kg). These samples were not analyzed for hexavalent chromium. As with the 1998 U.S.EPA investigation, the concentrations of chromium, lead, nickel, and zinc are below comparison values.

Only a handful of sediment and water samples have been analyzed for hexavalent chromium. Samples collected in Shipyard Creek did have detectable level of hexavalent chromium. Hexavalent chromium was also detected in on-site water samples collected in 1993. On-site concentrations of hexavalent chromium levels were extremely high (32 mg/L).

Although the area of significant contamination in the creek may be limited in scope (highest concentrations near the site), the creek and surrounding marsh are influenced by the tides. The tidal fluctuations may distribute contaminated sediment throughout the ecosystem. Shipyard Creek water samples collected at high tide tended to have higher metals concentrations than those collected at the same spot during low tide. Not only does sample location play a role in the level of site-related chemicals found in the creek, but when the sample was collected, high tide verses low tide. It is clear from this latest round of sampling, the chromium concentrations vary with the tide. Chromium concentrations may also change daily, depending on the environment in the system.

The differences in chromium concentrations in sediments from Shipyard Creek may also be due to ongoing oxidation and reduction of chromium. The reduction of chromium(VI) and the oxidation of chromium(III) in water has been investigated. The reduction of chromium(VI) by S-2 or Fe+2 ions under anaerobic conditions was fast, and the reduction half-life ranged from instantaneous to a few days. However, the reduction of chromium(VI) by organic sediments and soils was much slower and depended on the type and amount of organic material and on the redox condition of the water. The reaction was generally faster under anaerobic than aerobic conditions. The reduction half-life of chromium(VI) in water with soil and sediment ranged from 4 to 140 days (Saleh et al. 1989).

C. Quality Assurance and Quality Control (QA/QC)

The data in this section are from several different investigations at the site and represent the latest available information and data for this site. Quality Assurance and Quality Control (QA/QC) conclusions drawn for this public health assessment are determined by the validity of the analysis and conclusions made and the availability and reliability of the referenced information. SCDHEC assumes that adequate quality assurance and quality control measures were followed with regard to

chain-of-custody, laboratory procedures, and data reporting.

D. Physical and Other Hazards

The only physical hazards noted during the site visit are those associated with an industrial facility. The site is fenced with a guarded gate and access is restricted.

PATHWAYS ANALYSIS

The Pathways Analysis Section contains discussions of how chemicals move in the environment and how people can be exposed to those chemicals. Environmental monitoring data has shown that on-site surface water, soil, sediment, and waste materials are contaminated with site-related chemicals above screening levels. Sediments, surface water, and biota from Shipyard Creek also contained site-related chemicals. Groundwater at the site is also contaminated, however, a pump and treat remediation system was built in 1995 or 1996. North Charleston residents are on public water supplied through surface water and will not be exposed to contaminated groundwater water.

The chromium levels in Shipyard Creek samples have varied throughout the years. A recent drop in chromium concentrations in sediments and surface water may be due to a natural reduction of hexavalent to trivalent chromium or the result of remedial measures to reduce surface water runoff at the site. Storm water runoff investigations have previously reported significant runoff of surface water from the site into Shipyard Creek. Sediment collected from drainage pathways at the site have shown significant contamination with site-related chemicals. The fluctuations of chromium in Shipyard Creek and surface water on-site may be the result of ongoing changes in the form of chromium present in the samples. Most of the samples collected during investigations at the site were analyzed for total chromium. The creek and the marsh are not a stable system. The environment changes twice a day, as the tide changes. With these changes, may come fluctuations in the type and amount of chromium present in the samples. The hexavalent form is more relevant to environmental public health than is the trivalent form.

The hexavalent form (chromate) is the second most stable chromium compound and is a strong oxidizing agent, especially in acid media (Barceloux, 1999). In general, one expects hexavalent chromium to be reduced to the less toxic trivalent form of chromium. Depending on the redox conditions of the environment and the solubility of the chromium, chromium can become stagnated in the reduced (trivalent) form. The redox portion of the cycle boils down to simple transformations back and forth between trivalent and hexavalent chromium (Bartlett, 1991).

Several researchers have found that under certain conditions, the normal progression of hexavalent to trivalent chromium is slowed down. In addition, trivalent chromium can be oxidized to hexavalent chromium. Chromate will persist indefinitely in oxygenated water in equilibrium with aerobic sediment. However, stirring or mixing the sediment is likely to cause the exposure of less oxidized sediment to water which can cause reduction to the less toxic trivalent form of chromium. As the tide begins to rise in the Shipyard Creek system, the sediments are mixed with oxygenated water thereby increasing the reduction of hexavalent chromium to trivalent chromium. Therefore, one would expect that trivalent chromium would predominate in Shipyard Creek. However, oxidized chromium or hexavalent chromium may persist indefinitely in the aerated water above an undisturbed sediment-water interface. If there is mixing across this interface, the hexavalent chromium will be reduced to trivalent form (Bartlett, 1991).

Some hexavalent chromium can be protected from reduction by adsorption. More highly weathered southern soils dominated by oxide-rich materials adsorbed more hexavalent chromium than less weathered soils. Organic acids can enhance oxidation and reduction of chromium (Bartlett, 1991).

The presence of manganese can also affect the normal progression of hexavalent to trivalent chromium. The presence of manganese oxides can enhance the oxidation of trivalent to hexavalent chromium. Other oxides such as iron and sulfur, can enhance the reduction of hexavalent chromium to trivalent chromium (Rai et al. 1989). Some sediment samples collected in Shipyard Creek did contain elevated levels of manganese and iron. It is possible that the reduction of hexavalent chromium to trivalent chromium and the oxidation of trivalent to hexavalent can take place at the same time. If the trivalent chromium is not in a form that is mobile or can be mobilized, it will not be oxidized in spite of optimum manganese oxide surfaces (Bartlett, 1991).

There are two types of exposure pathways, completed and potential, evaluated in public health assessments. Completed exposure pathways mean that we are sure that someone has been exposed to site-related chemicals. For example, there must be a source of the chemical (the site); must be contaminated media at the site (soil); must be a way people can be exposed (we know people are getting on the site); and we know people have been exposed (they are eating the dirt). There are no completed exposure pathways associated with the site.

The second type of exposure pathway is a potential exposure pathway. This means we do not have all the information we need to determine whether exposure has occurred or will occur in the future. For example, if we know that groundwater at the site is contaminated and there is a water supply well nearby that could at some point in the future become contaminated, it is called a potential exposure pathway. The potential exposure pathways for the community around the Macalloy Site are shown in Table 1.

On-site soil, surface water, sediment, and waste are contaminated with very high levels of some site related chemicals, especially chromium. On-site waste materials also had high levels of lead and manganese. Waste materials were stored on site and used as fill across the site, so it is possible that on-site workers could have been exposed to these materials during operations at the facility. We do not know if anyone, other than workers, has been on the site frequently enough or at all, to have been exposed to site-related chemicals in the soil, surface water, sediment, and waste material. We do not have any specific exposure information to determine if on-site workers have been exposed to these chemicals. We can only assume that they may have been exposed during their normal work day. Because we do not have any information to conclude that workers have been exposed to on-site contamination, on-site soil, surface water, sediment, and waste material represents a past potential exposure pathway. This means that it is possible for workers and trespassers to have been exposed to chemicals on the site while the facility was still open. The plant closed in 1998 and exposure to the workers at the plant has ceased. It is unlikely that nearby residents have been exposed to the contaminated materials on-site, because the property is secured by a fence and a guard and current soil levels are much lower than they were in the past.

In addition, we know shrimp, crabs, sediment, and surface water in Shipyard Creek are contaminated with chromium (at one time). The biota samples were analyzed for total chromium and the type of chromium present in the tissues was not speciated. From March 2000 until November 2001, SCDHEC had a consumption advisory in place for shrimp from Shipyard Creek. It is possible that people catching and eating shrimp and blue craps in the past may have been exposed to chromium. However, additional data collected in November 2001 indicated much lower levels of chromium than what was found in previous investigations and the advisory was lifted.

People wading in the marshes to go fishing could be exposed to chemicals in the sediments. Although it is possible that people wading in the marshy areas (while shrimping or crabbing) could have been exposed to chromium, more recent data (1998 and 2001) show much lower levels of chromium. We have no data to determine what chromium levels were in the past. It is likely that sediment concentrations were higher because of uncontrolled runoff from the site into Shipyard Creek. A sediment sample collected in 1995 contained very high levels of chromium. If sediments were contaminated with only trivalent chromium the risk from contact with sediments was likely to be minimal. If, however, sediments contained significant amounts of hexavalent chromium, contact with these sediments could have posed a health risk in the past. It is likely that sediment concentrations were much higher in the past because of uncontrolled runoff from the site to Shipyard Creek. The 1997 U.S.EPA Stormwater Inspection reported "sitewide surface water runoff forming gullies and canals discharging unabated to Shipyard Creek". This same report also stated that there was "evidence of contaminated runoff along the entire water edge". (U.S.EPA, 1997).

In June 1998, the Macalloy Corporation installed interim surface management controls via a CERCLA Section 106 Removal Action Administrative Order of Consent (AOC) with EPA. This action involved the construction of berms, diversion structures, and detention basins to facilitate removal of solids from stormwater run-off, before discharge. This action eliminated most if not all of the uncontrolled surface water runoff from the site. It is likely this action which has resulted in a decrease in chromium concentrations in Shipyard Creek sediments.

Table 1

Potential Exposure Pathways

Exposure Pathway Elements

Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population	Time
Macalloy Corporation	Waste Material/Dust	On-site	Ingestion, Inhalation of Dust	Workers	Past
Macalloy Corporation	Sediment in Shipyard Creek	Shipyard Creek	Dermal Contact	People wading in the marshes.	Past
Macalloy Corporation	Biota in Shipyard Creek	Shipyard Creek	Ingestion	People catching and eating shrimp and crab caught near the site in Shipyard Creek.	Past

PUBLIC HEALTH IMPLICATIONS

A. Toxicological Evaluation

There is often little information about the health effects caused by low level environmental exposures. Most human exposure studies use information from industrial exposures, where the doses are much higher. Industrial exposure data normally do not include precise information about the dose, the purity of the chemicals, their interactions with other

substances, and the duration of the exposure. For some chemicals, there is no information available on the effects in people; therefore, we use data collected from studies using laboratory animals. Animals do not necessarily show the same responses that humans do when exposed to toxic substances. However, in animal experiments using carefully controlled doses and time periods, researchers observe health effects that they believe may also occur in people.

Information is not available to be able to say with certainty that if a person were exposed to chemicals at the site they would become sick. Most information about these chemicals is usually obtained from laboratory studies. The animals in these studies are typically exposed at much higher levels than would be expected to occur at the Macalloy Site. It is very difficult to know what levels of these chemicals at the site can cause specific health effects. The kinds and severity of human health problems that can occur with exposure depend upon several factors: the amount of chemical exposure, duration of exposure, and route of exposure; body weight, age, sex, ethnic background, lifestyle factors, and genetic factors; general health of the person; individual reactions to chemicals; and, interactions with other chemicals or drugs.

In order to compare the amounts of a substance taken into the body to known standards, this section uses comparison doses. These doses are based on the amount of a substance that is consumed per day (milligrams/kilogram body weight/day, mg/kg/day). Comparison doses used in this section include ATSDR's Minimum Risk Level (MRL), which represents an estimate of daily human exposure to a dose of a chemical that is likely to be without adverse effects (for noncancerous effects) over a specified duration of exposure, and the U.S.EPA Reference Dose, which is an estimate of the daily exposure of people to a hazard that is likely to be safe during a lifetime (that does not include cancer). These doses represent levels at which harmful effects are unlikely to occur. They are calculated using safety factors for the most sensitive human populations, and if based upon animal measurements, additional factors are used.

A level of concern is an estimated dose, below which, adverse health effects are not expected to occur. Levels of concern are normally U.S.EPA reference doses or ATSDR MRLs. This does not mean that if the estimated dose of the chemical is above these levels of concern a person will become sick, but that there is an increased risk that exposure could cause adverse health effects

in people exposed.

Elevated levels of total chromium and hexavalent chromium have been found in on-site soil, surface water, sediment, and waste materials. Elevated levels of total chromium have also been found in surface water and sediment in Shipyard Creek. Since it is not known what the levels of hexavalent chromium were in the past, it is possible that sensitive people who waded in the creek could have developed an allergic skin rash. Limited monitoring data shows the presence of hexavalent chromium in surface water. Current levels of hexavalent chromium are low and are not likely to pose a risk to people wading in the marshes.

If the chromium in sediments is in the hexavalent form, the concentrations are high enough to cause adverse reactions following prolonged contact. It has been shown that exposure to concentrations of hexavalent chromium as low as 10 mg/kg can cause adverse effects (Bagdon RE and Hazen, RE, 1991). Other studies have shown that soil concentrations of hexavalent chromium at levels higher than 300 mg/kg should not cause allergic dermatitis (Felter and Dourson, 1997; Nethercott et al. 1994). One sediment sample from Shipyard Creek contained 20,660 mg/kg of chromium.

Dermal absorption depends on the physical and chemical properties of the compound, the vehicle, and the integrity of the skin. Both chromium(III) and chromium(VI) can penetrate human skin to some extent, especially if the skin is damaged. Systemic toxicity has been observed in humans following dermal exposure to chromium compounds, indicating significant cutaneous absorption. Dermal contact in chromium sensitized individuals can also lead to allergic dermatitis. The risk of sensitization to hexavalent chromium depends on the duration and amount of exposure (Barceloux, 1999). Hypersensitive individuals may develop rashes and erythema from contact with contaminated soil or consumer products containing chromium. Dermal exposure of animals to chromium(VI) and chromium(III) compounds have also resulted in skin ulcers and allergic response (ATSDR, 1998). Soil concentrations below 500 ppm should provide adequate protection against the development of allergic contact dermatitis, respiratory cancer, and systemic toxicity (Felter and Dourson, 1997, as seen in Barceloux, 1999).

Chromium is a naturally-occurring element that is found in three major forms: chromium (0), chromium (III), and chromium (VI). In animals, the digestive tract is the primary route of chromium uptake; however, absorption is slow and depends on the valence state of chromium. Chromium (VI) is more easily absorbed than chromium (III). Once absorbed, however, most chromium (VI) is changed to chromium (III). Chromium (VI) can cross cell membranes easily where it forms chromium-protein complexes which cannot leave the cell. Chromium(VI) is better absorbed from the lung, gastrointestinal tract, and skin than is chromium (III) (ATSDR, 1998).

Besides the respiratory effects, exposure to chromium(VI) and (III) compounds can be associated with allergic responses (e.g., asthma and dermatitis) in sensitized individuals. Chromosome aberrations have been observed in some humans occupationally exposed to chromium(VI) compounds and other substances. Oral exposure of animals to chromium(VI) and chromium(III) compounds have resulted in gastrointestinal, hepatic, renal, immunological, neurological, developmental, and reproductive effects (ATSDR, 1998).

The body possesses mechanisms in the lung and stomach to reduce hexavalent chromium to the less toxic trivalent chromium. At low levels of exposure to hexavalent chromium, the body has the potential to reduce hexavalent chromium to trivalent chromium. However, there may be a threshold above which the body does not as easily reduce the chromium (Barceloux, 1999). Individuals who convert chromium (VI) to chromium (III) slowly have higher blood levels of chromium. There are differences in the ability of individuals to reduce chromium in the plasma, ie fast and slow reducers (Barceloux, 1999). The slow reducers might have increased susceptibility to the kidney and liver toxicity of chromium, however, clinical evidence for this is lacking. In some animal species, pre-exposure to chromium may lead to slower

elimination of the chemical from the body (Outridge and Scheuhammer, 1993). Chromium interacts with several other substances. Potassium dichromate, given by injection, increased the effects of the following kidney poisons: mercuric chloride, citrinin, and hexachloro-1,3-butadiene. Chromium nitrate and mercuric chloride also interact with the transport of substances in the kidneys. Other studies indicate that chromium (VI) can enhance the effects of agents that damage DNA. The damaging effects of hexavalent chromium, occurring as it is reduced to trivalent chromium, appear to stem from its greater membrane permeability, which allows it to cross biological membranes and oxidize cellular components not normally accessible to trivalent chromium (Saner, 1980; as seen in Outridge and Scheuhammer, 1993). Hexavalent chromium is considered a human carcinogen. Elevated rates of lung cancer have consistently been found in workers occupationally exposed to chromium (ATSDR, 1998)

Chromium III is an essential micro-nutrient and is important for the normal metabolism of glucose, fats, and protein. If a person were to consume food or water containing high concentrations of hexavalent chromium, it can cause stomach upsets and ulcers, convulsions, kidney and liver damage. The levels seen in seafood from Shipyard Creek are high, but they are not high enough to cause these adverse effects. If someone ate large amounts of shrimp, several times a week, they could develop gastrointestinal problems, including indigestion, abdominal pain, vomiting, and diarrhea.

On-site sediment, surface water, and waste material contained high levels of lead. There is no U.S.EPA reference dose for lead so it is difficult to determine what levels of exposure are harmful. Children are at greatest risk of adverse health effects from exposure to lead. Exposure to lead can result in elevated blood lead levels. Elevated blood lead has been associated with decrease in intelligence (IQ) scores, slow growth, and hearing problems in children and infants. These effects can happen at low exposure levels and persist as the children get older. Adults do not absorb lead readily via the digestive tract, whereas children absorb lead more readily. Most absorbed lead is stored in bones. Lead is also distributed to the red blood cells, blood plasma, kidney, liver, and brain. This storage is cumulative and the body's burden increases over time (ATSDR, 1999)

Elevated levels of manganese were also found in some on-site samples, primarily dust. As with trivalent chromium, manganese is also important in maintaining your health. However, too much manganese can have adverse health effects. Manganese miners or steel workers exposed to high levels of manganese dust in air may have mental and emotional disturbances, and their body movements may become slow and clumsy. These symptoms can result from several years of manganese exposure in the workplace. The area most sensitive to manganese exposure is the nervous system (ATSDR, 1992).

Child Health Issues

SCDHEC's evaluation contained within this document considered children as a susceptible subpopulation. Children may be more likely to wade in the creek, therefore, more likely to come in contact with contaminated sediments. Children can have a greater exposure than adults because they typically play outside for longer periods and are attracted to playing in

water, resulting in a greater duration of exposure than adults. Children also have a two-to three times greater ratio of body surface area by weight than adults (U.S.EPA, 1997), so a similar exposure can have a greater effect on a child.

It is unlikely that children would be exposed to contaminated materials on-site, because the facility is secured by a fence and access is controlled by a guard.

B. Health Outcome Data Evaluation

No health outcome data are readily available for the area of North Charleston where the Macalloy site is found. SCDHEC has not received any information showing that the community has specific health concerns. Involvement at the site is in its initial stages, and a review of health outcome data may be considered in the future or as citizens become more involved at the site.

C. Community Health Concerns Evaluation

HHE contacted the SCDHEC Environmental Quality Control and Health District offices for information regarding health concerns related to the Macalloy site. Neither of the offices have reports of site-specific health concerns. In June 2000, the U.S.EPA held a public meeting to initiate their activities at the site. None of the residents at this meeting reported any health concerns to EPA staff.

CONCLUSIONS

ATSDR classifies sites as to their public health hazard category. Under ATSDR's classification system, the Macalloy site would be classified as an indeterminate public health hazard in the past. It is possible that former workers were exposed to lead, chromium, and manganese while working at the facility. However, we have no information to fully evaluate this exposure pathway. It is also possible that people catching and eating shrimp and blue crabs caught near the site could have been exposed to chromium. Current chromium concentrations in shrimp are below levels of concern.

Currently, the site poses no apparent public health hazard. This means that based on current conditions at the site, we do not think people are being exposed to site-related chemicals at levels that would cause adverse health effects.

Most of the monitoring data collected as part of RCRA investigations that are not done to determine the risk to public health. Typically, RCRA investigations do not entail collecting a large number of samples and may only analyze samples for limited number of chemicals. Most of the samples collected in the early investigations at the Macalloy site were only analyzed for eight RCRA metals. Chromium can be found in several different forms; trivalent and hexavalent chromium are most often associated with industrial facilities. Until recent investigations, only a few samples had been analyzed for hexavalent chromium. We will never be able to recreate conditions at the site while the facility was in operation. We do know that at one time very high levels of chromium, lead, and manganese were found onsite.

RECOMMENDATIONS

1. SCDHEC-HHE will review the information collected as part of further (if any) investigations at the Macalloy site.

PUBLIC HEALTH ACTION PLAN

SCDHEC-HHE will review the information collected as part of further (if any) investigations at the Macalloy site.

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CERTIFICATION

This Macalloy Corporation Public Health Assessment was prepared by the South Carolina Department of Health and Environmental Control's Division of Health Hazard Evaluation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry. It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this health assessment, and concurs with its findings.

Roberta Erlwein

Chief, SSAB, DHAC, ATSDR

APPENDIX A, FIGURES

APPENDIX B, DATA TABLES

TABLE 1

1994 RCRA INVESTIGATION

CHEMICAL	SAMPLE TYPE			
	Surface Water (ppm)	**Sediment (ppm)**	**Dust (ppm)**	**Water/Sediment Comparison Values (ppm)**
Chromium	8.3-530	3,100	3,400-6,100	0.1[1]/2,100[2]
Hexavalent Chromium	7.2-32J	NA	NA	0.1[1]/2,100[2]
Nickel	ND-14	610	120-580	0.7[1]/1,600[2]
Lead	ND-100	580	670-1,700	0.015[1]-1,500[3]
Mercury	ND-0.031	0.2	0.36-0.46	0.002[1]/210[2]
Manganese	ND-340	1,100	94,000-250,000	840[4]/47,000[4]
Zinc	28-940	2,300	3,400-10,000	11,000[4]/610,000[4]

1=U.S.EPA MCL

2=Comparison Value for Sediment/Soil calculated by SCDHEC/HHE

3=U.S.EPA Industrial Soil Screening Level

4=U.S.EPA Region III Risk Levels for Water and Soil/Sediment

ND=Not Detected

NA=Not Analyzed

TABLE 2

1997 U.S.EPA RCRA STORMWATER INSPECTION

CHEMICAL	SAMPLE TYPE		
	Surface Water (ppm)	**Sediment (ppm)**	**Water/Sediment Comparison Values (ppm)**
Chromium	ND-10,000	320-4,700	0.1[1]/2,100[2]
Hexavalent Chromium	ND-0.94	NA	0.1[1]/2,100[2]
Lead	ND-0.21	12-630	0.015[3]/1,500[4]
Manganese	0.11-2.4	250-2,000	840[5]/47,000[5]

1=U.S.EPA MCL

2=Comparison Value for Sediment/Soil calculated by SCDHEC-HHE

3= U.S. EPA Action Level

4=U.S.EPA Industrial Soil Screening Level

5=U.S.EPA Region III Risk Level for Water and Soil/Sediment

ND=Not Detected

NA=Not Analyzed

TABLE 3

CHROMIUM CONCENTRATIONS IN BIOLOGICAL SAMPLES

Species	Concentration (mg/kg)	Mean (mg/kg)
Blue Crab	0.14-24.3	7.13
Eastern Oyster	2.7-34.3	8.18

Shrimp	7.5-77.8	27.3

Comparison Values-See Appendix C.

TABLE 4

1998 U.S.EPA INVESTIGATION

CHEMICAL	**SAMPLE TYPE**		
	Surface Water (ppm)	**Sediment (ppm)**	**Water/Sediment Comparison Values (ppm)**
Chromium	ND-2.6	32-3,850	0.1[1]/2,100[2]
Hexavalent Chromium	0.013-2.6	ND-21.3	0.1[1]/2,100[2]
Lead	ND-0.013	7-615	0.015[3]/1,500[4]
Nickel	ND-0.14	ND-715	0.7[1]/1,600[5]
Zinc	ND-0.73	34-4,790	11,000[5]/23,000[5]

1=U.S.EPA MCL

2=Comparison Value for Sediment/Soil calculated by SCDHEC-HHE

3=U.S.EPA Action Level

4=U.S. EPA Industrial Soil Level

5=U.S.EPA Region III Risk Level for Water and Soil/Sediment

APPENDIX C, CONSUMPTION LEVELS FOR CHROMIUM

A risk-based procedure for chromium in seafood was used to assess the risk from consuming shrimp/crab in Shipyard Creek. It assumes an average meal size of 227 grams (g) (1/2 pound average meal) and the following consumption rates: 140 g shrimp, crab or oysters per day or 225 meals a year for the unrestricted consumption category; 32 g/day for 1 meal a week; 7.4 g/day for 1 meal a month; and 3.7 g/day for 6 meals a year. This last category can serve as a vacationers category. The Advisory is categorized under the following groupings:

Group 1

Unrestricted consumption:

raw sample with

0-2.0 ppm Chromium

Group 2

1 meal a week-52 meals a year:

raw sample with

2.1-7.0 ppm Chromium

Group 3

1 meal a month-12 meals a year:

raw sample with

7.1-30 ppm Chromium

Group 4

6 meals/year:

raw sample with

30.1-56.0 ppm Chromium

Group 4

Do not Eat:

>56 ppm Chromium